South Asian Regional Report on the Issues and Activities Associated with Coral Reefs and Related Ecosystems

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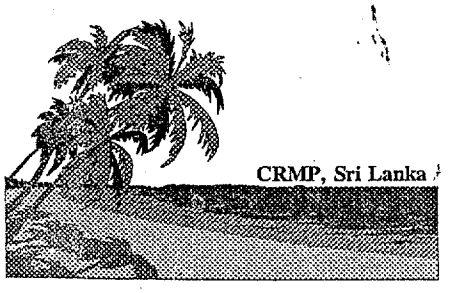

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SOUTH ASIAN REGIONAL REPORT ON THE ISSUES AND ACTIVITIES ASSOCIATED WITH CORAL REEFS AND RELATED ECOSYSTEMS

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INTRODUCTION

This report describes the status and management of coral reefs in the countries of South Asia (Bangladesh, Chagos Archipelago (British), India, Maldives, Pakistan and Sri Lanka). It also provides information on the status of seagrasses and mangroves depending on the availability of references. It draws information from Coral Reefs of the World, Indian Ocean, Red Sea and Gulf, Volume 2, published by UNEP/IUCN in 1988. More recent information is cited as available and analyzed to show the most recent trends in resource condition, use and conservation. Maps show the important reef locations. Summaries of reef condition and status, current research and management projects and recommendations are included.

South Asian Region, Reefs and related Ecosystems

The South Asia Region located in the northern Indian Ocean is divided by the Indian land mass into the Arabian Sea and the Bay of Bengal, both of which have areas of broad continental shelf but few offshore islands. Coral reef growth is inhibited by massive fresh water and sediment inputs from the Indus, Ganges and other smaller rivers and in the northwest by cold upwelling (UNEP/IUCN, 1988; Scheer 1984; Stoddart, 1971). In contrast, the richest growth of mangrove forest is along the major river mouths and deltas.

Mainland India has two widely separated areas of reef development, in the northwest and southeast. Sri Lanka has shallow fringing reefs and coral communities on sandstone outcrops along about half of its coastline (Figure 1). There are almost no reefs in Bangladesh and Pakistan due to high turbidity, although mangroves thrive along the river deltas of these countries. On the eastern side of the Indian Ocean, fringing reefs are found on offshore islands and on some mainland coasts. The Andaman and Nicobar Islands (India) arise from a submerged mountain chain which follows a southward extension of the continental shelf. They have good fringing reef development and mangrove forest. The other main coral reef structures in this region are found in the atoll chain on the Laccadive-Chagos ridge (Figure 1). This includes the Laccadive Islands (Lakshadweep, India), the Maldive Islands and atolls and the Chagos group (British Territory) comprising a number of poorly known large submerged coral-limestone banks (UNEP/IUCN, 1988). The developed reef systems around the south Indian coast, Andaman and Laccadive Islands and the northwest coast of Sri Lanka all support large seagrass beds either within or adjacent to the area.

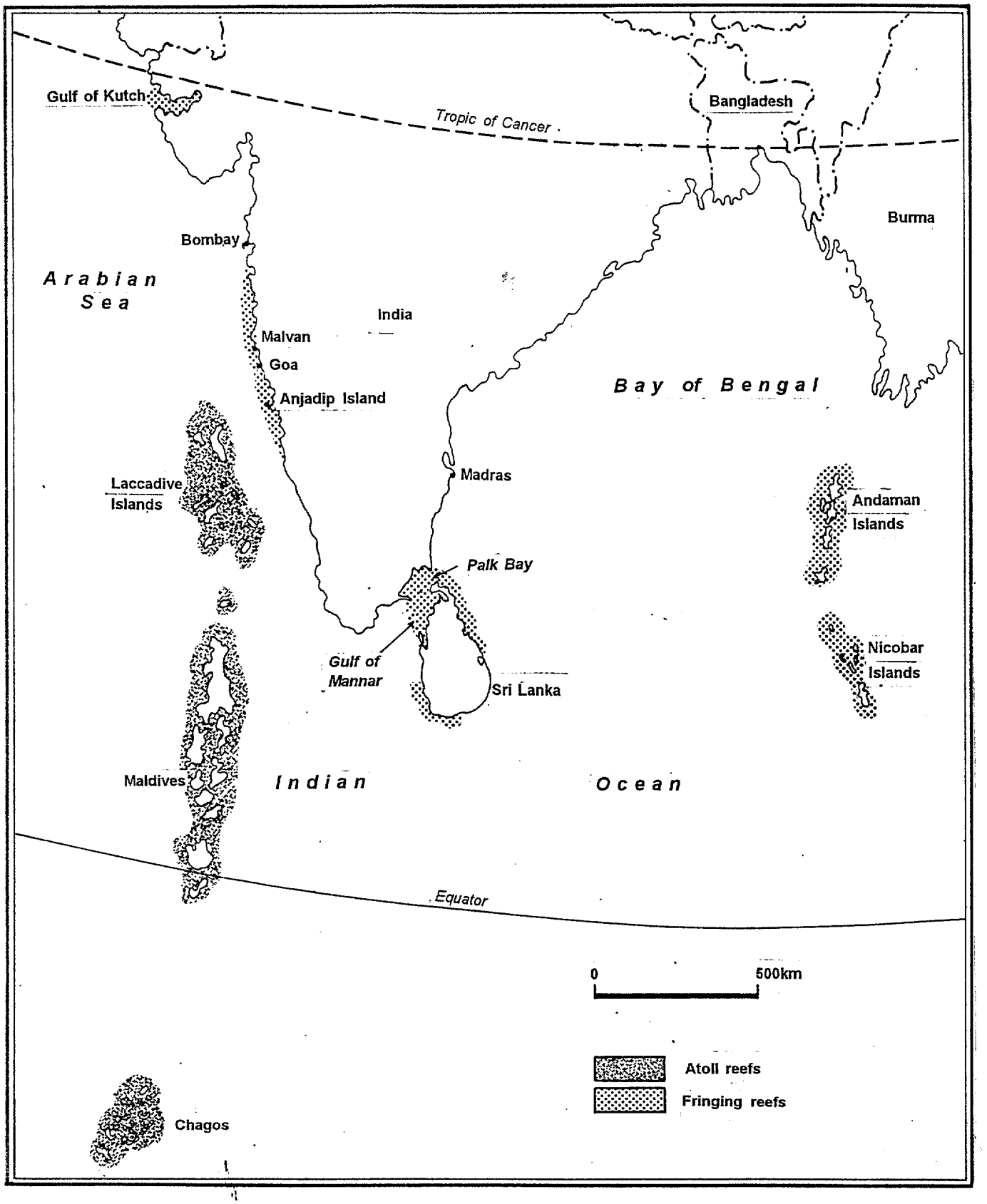

Figure 1. South Asia countries and sites with coral reefs (UNEP/IUCN 1988)

COUNTRIES, COASTAL ECOSYSTEMS AND THEIR STATUS

Bangladesh

Coral Reefs. St. Martin's Island is the only coral reef island in Bangladesh. This gradually eroding island lies about 10 km south of the mainland and is about 8 km long and 1.6 km wide (Anwar 1988; Holmgren 1994; Haque et al 1979). Limited scientific surveys have identified 13 coral genera on the island reef and noted that the shallow-sandy littoral area is partially covered with seagrass. Management status of this island is unknown but the reef environment is reported to be degraded (Fattah 1979; De Silva 1983).

The main threats to the coral reefs are from sedimentation, cyclones and storm surges, destructive fishing methods, removal of corals for lime production and construction, boat anchoring and some pollution. Corals and shells are removed for sale as souvenirs. Sea urchins and starfish are also collected in bulk (Ahmed 1995). Although several species of sea turtles nest on the island beaches, collection of eggs and killing of turtles threaten their use of the island habitat (Ahmed 1995).

Seagrass growth in Bangladesh is very limited due to the seasonal fluctuations in salinity and heavy sedimentation in nearshore areas (Jameson et al 1995).

Mangrove. Bangladesh, with the largest river delta in the world, formed by the Ganges, Brahmaputra and Meghna rivers, has extensive habitat for mangroves. The total extent of mangroves in 1990 was 7690 sq km (Spalding et al 1995). The Sunderbans mangrove forest, which makes up most of the western coastal area, covered 750 sq km in 1975. Now, less than 100 sq km remain of the Sunderbans forest because of conversion to aquaculture. The primary threats to mangroves in Bangladesh are conversion to aquaculture and cutting for fuel wood and timber. Cyclone winds and storm surges also pose severe threats and could be exacerbated with climate change and sea level rise (Edwards 1995). There is apparently no active management or conservation of mangroves in Bangladesh (Spalding et al 1995).

Chagos Archipelago

Chagos lies on the southernmost and oldest part of the Chagos-Laccadive ridge, in the geographical center of the tropical Indian Ocean (Figures 1 and 2). There are five atolls with islands. In addition, the central feature is the Great Chagos Bank, probably the world's largest atoll in terms of area, is mostly submerged but has eight islands on its western and northern rim, including Nelson, Three Brothers, Eagle and Danger (UNEP/IUCN, 1988). It is surrounded by mostly submerged smaller atolls and shoals

and Diego Garcia to the south (Figure 2). The total area of shallow water is about 21,000 sq km (UNEP/IUCN, 1988).

All atolls and submerged banks are actively growing reefs. Chagos contains the largest expanse of totally undisturbed reefs in the Indian Ocean, as well as some of richest. About 200 species of scleractinian corals have been recorded with one endemic species. The islands are important breeding grounds for Green and Hawksbill turtles and support substantial populations of the Coconut crab Birgus latro and nesting seabirds.

The islands are uninhabited except for Diego Garcia which is now a United States military base. Some islands have been modified for coconut plantations in the past and little remains of the original terrestrial biota. The reefs are largely undisturbed except possibly those lying within the lagoon of Diego Garcia. The only other disturbance is visiting yachtsmen (UNEP/IUCN 1988).

Chagos or the British Indian Ocean Territory is claimed by Mauritius. A 1966 Treaty Agreement provides that the whole of the Chagos Archipelago shall be available for defence purposes. Under Ordinance 2 of 1968, the British Commissioner has powers to make regulations for the preservation of wildlife. The collection, possession and sale of Green turtles are prohibited under this Ordinance.

The inaccessibility and uninhabited nature of all the islands except Diego Garcia protect the archipelago but there is no legal protection. Any formal undertaking to protect the wildlife in and around the islands could conflict with its designation for defence purposes (UNEP/IUCN 1988).

Formal protection of the reefs around Chagos has been recommended by Bellamy (1979) and Sheppard (1980; 1981). The archipelago contains the largest expanse of undisturbed reefs and the highest known diversity of corals and molluscs in the Indian Ocean; and the smaller islands have very large seabird populations, original hardwood vegetation, notable Hawksbill turtle nesting beaches and the threatened Coconut crab. Nelson Island has been recommended as a nesting reserve for Green turtles and frigatebirds (Frazier, 1977). The Corbett Action Plan for Protected Areas of the Indomalayan Realm has identified Chagos as an area with marine conservation needs (Thorsell, 1985; UNEP/IUCN 1988). The healthy condition of reefs in Chagos is probably their best defense against the effects of sea level rise (Edwards 1995).

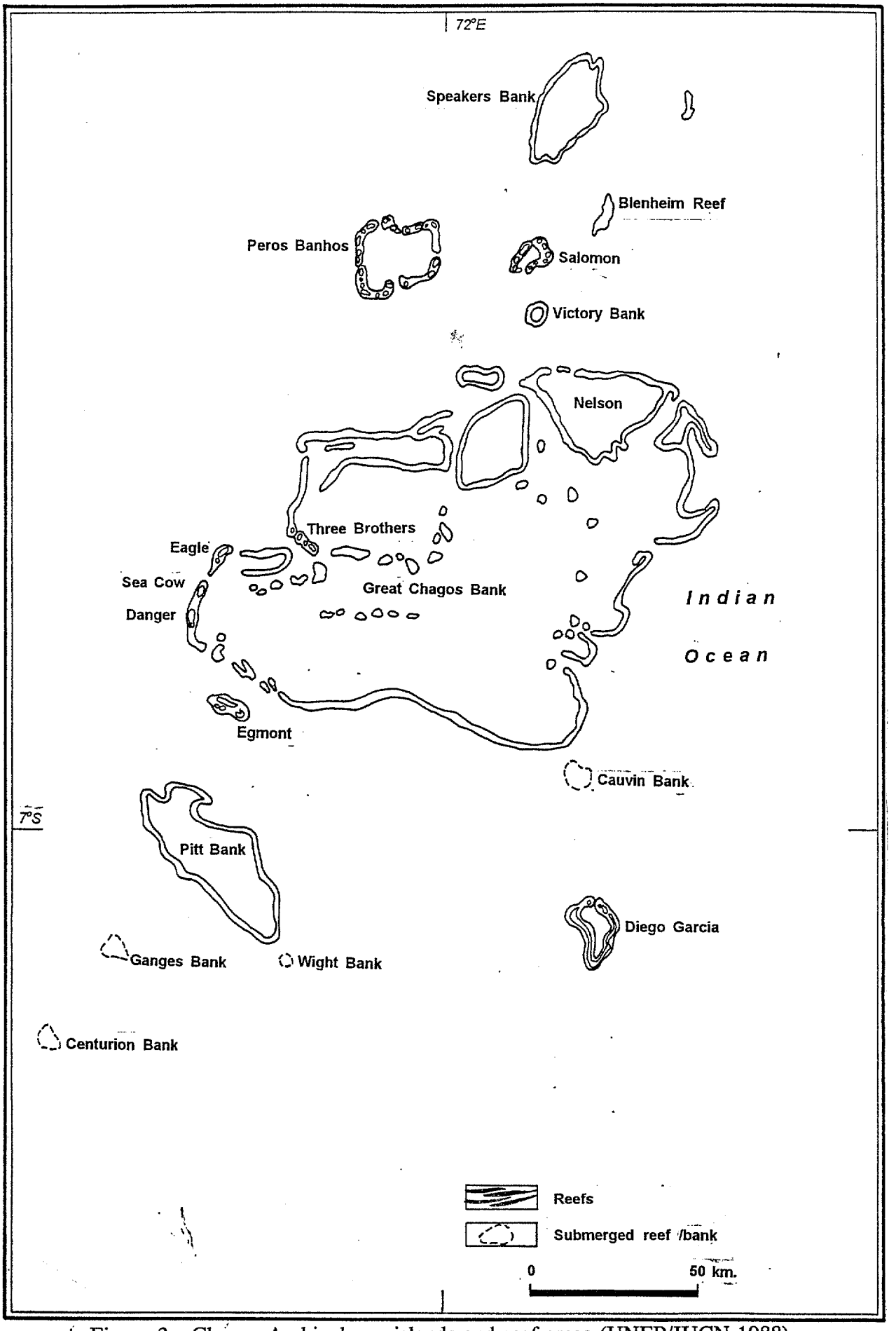

Figure 2. Chagos Archipelago, islands and reef areas (UNEP/IUCN 1988)

India--Mainland Coast and Island Groups

Coral reefs are present on only a few widely scattered locations off the mainland coast: the Gulf of Kutch in the northwest; off the southern mainland coast; and around a series of small islands opposite Sri Lanka (Figures 1 and 3). Major river systems and the sediment regime on the continental shelf inhibit reef growth in most areas. Reefs off the mainland coast and on nearshore islands are mainly fringing and shallow with only 5 meters depth.

The Gulf of Kutch has many islands on its southern side, around which are shallow reefs, often backed by mangroves. In the southeast, Palk Bay has a long fringing reef. To the southwest of the Mandapam Peninsula and Rameswaram Island, the Gulf of Mannar has about twenty small islands and numerous reefs which extend as far south as Tuticorin (Mergner and Scheer 1974). The corals of these shallow reefs are much more diverse than further north. Table 1 lists the Gulf of Mannar islands and their island area. The Gulf of Mannar is a feeding ground for Green turtles and resident Dugong.

Important offshore island groups of India with extensive reef growth include the Andaman and Nicobar Islands in the eastern Indian Ocean and the Laccadive Islands off the southwest coast of India. The Andamans comprise about 500 islands. Coral reefs are fringing, and often several hundred meters wide. About 300 km south of the Andaman Islands lie the Nicobars. These high islands have much fringing reef growth with reef flats extending up to 1 km from the island. Recent surveys in the Andaman and Nicobar Islands covered 110 locations in 45 reef areas. Some reefs were in pristine condition and others much degraded (Wafar and Whitaker 1992; Dorairaj 1994). The Laccadive Islands are part of the largest group of atolls in the Indian Ocean. There are 11 major islands (36 total) and lagoons (atolls), 4 major submerged reefs and 5 major submerged banks.

Coral species recorded for all Indian reefs is 207 in 55 genera (Pillai 1971; 1972). Important features and parameters of the Indian island groups with reefs are summarized in Table 2.

Coral reefs off the mainland coast are all heavily exploited for saleable products. Ornamental shells are a primary target as are shells with mother-of-pearl such as Trochus and Turbo genera. Sea fans and seaweeds are exported (13 tons annually) as are sea cucumbers, spiny lobster and sea horses. Reef fisheries are generally subsistence and unrecorded but may provide about 10% of the total marine fish production in India (UNEP/IUCN 1988).

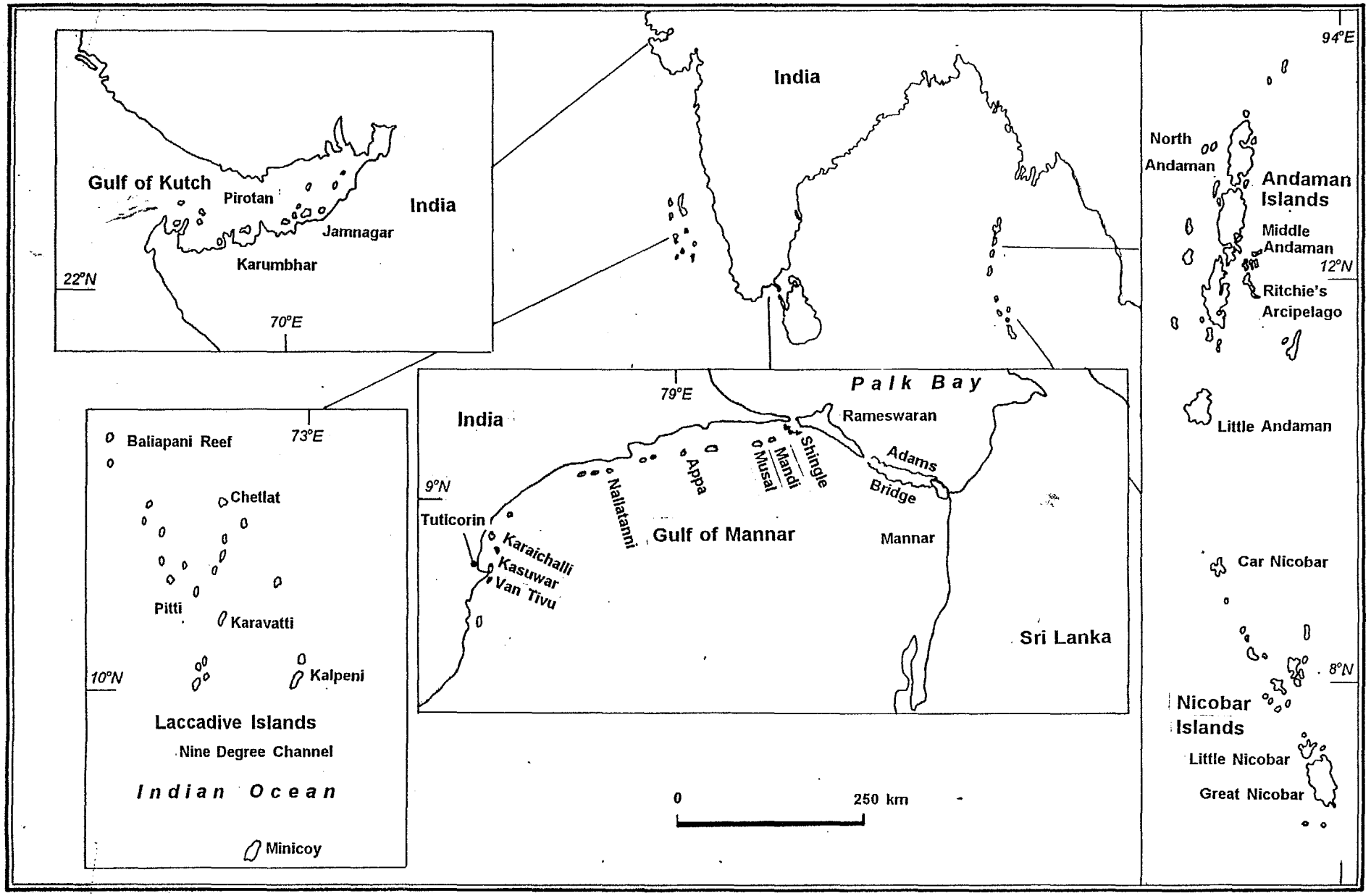

Figure 3. Indian mainland and island groups with coral reefs
(UNEP/IUCN 1988)

Table 1. Islands with fringing reefs, Gulf of Mannar, India

Group Name	Islands	Island** Area (ha)
Tuticorin Group	Van thivu*	16
	Kasuwar thivu	19
	Karaichalli thivu	16
	Velanguchalli thivu	6
Vembar Group	Upputhanni thivu	30
	Polvinichalli thivu	6
	Nallathanni thivu	110
Kilakkarai Group	Anaipur thivu	11
	Vallimunai thivu	7
	Poorarasanpatti thivu	0.5
	Appa thivu	29
	Talairi thivu	75
	Velai thivu	10
	Mulli thivu	10
Mandapam Group	Musal thivu	129
	Manoli thivu	26
	Manoliputti thivu	2.5
	Poomarichan thivu	17
	Pullivasal thivu	30
	Krusadai thivu	~66
	Shingle thivu	~13

* thivu in Tamil means island

** Total area of islands approximately 600 ha

Sources: Ramanujan, 1994 (unpublished); UNEP/IUCN 1988

Various kinds of pollution affect many of the mainland coastal reefs although sedimentation is the main concern. Oil pollution and industry have caused significant damage in the Gulf of Mannar and Palk Bay area (UNEP/IUCN, 1985). Also, flyash discharge from a thermal power station at Tuticorin has destroyed pearl oyster beds (Dhandapani 1995). Blast-fishing and sand extraction are persistent problems. Coral mining, in the same area, removes an estimated 80,000 cubic meters yearly (Venkataramanujam et al 1981; Wafar and Whitaker, 1992; Ramanujam, 1994). Coral mining also occurs in the Gulf of Kutch where some reefs have been totally destroyed.

Remote sensing surveys for the Gulf of Kutch conducted in 1975, 1982, 1985 and 1988 documented changes in coral reef, mangrove, seagrass and other parameters. The images showed a decline of coral reef cover within the Gulf of Kutch Marine National Park from 117 sq km in 1975 to 53 sq km in 1985, and a partial recovery of 28 sq km in 1988 (Wafar and Whitaker 1992). Recovery is attributed to enforcement of laws to stop mangrove cutting and coral mining.

In general, the condition of fringing reefs off the mainland is poor. Most or all have deteriorated as a result of various human impacts of which sedimentation is the most significant.

Seagrass beds occur in shallow sheltered bays along the coasts of Tamil Nadu and into the northern part of the Gulf of Mannar. In the Laccadives, dense meadows are present in the lagoons of Minicoy, Kavaratti and Agatti Islands. Seven species occur in the Laccadive Islands while 12 species in 7 genera are recorded from all coastal areas of India (Jagtap 1991).

Mangrove areas are patchy and spread along the mainland Indian coastline. Most of India's mangroves grow along the east coast where well developed estuaries are located. The most extensive forests are in the Indian section of the Sunderbans bordering Bangladesh. The Andaman and Nicobar Islands host much mangrove growth with the forests in the Nicobar Islands in excellent condition. They also occur in the Lakshadweep Islands. On the west coast, mangroves fringe estuaries of many small rivers and along the arid coast of the Gulf of Kutch. There are 59 species of mangroves and associated species recorded for India. Twenty-five species are endemic to the east coast while 8 species are found only in the west coast. Estimates of mangrove cover in India range from 3,565 to 6,700 sq km (Spalding et al 1995). The higher number is apparently most accepted.

Human use of mangrove products is intense in India. The Sunderbans alone has a resident population of about 2 million people. Mangroves are important for fuelwood, fisheries production, honey production and the use of Nypa palm. In the Gulf of Kutch

about 10,000 people exist by selling mangrove wood for fuel. Aquaculture is expanding particularly in the east coast. Large areas have been reclaimed for agriculture and urban development. Bombay is built on reclaimed area between 7 islands that supported mangrove stands. Over exploitation of mangrove products and conversion of mangrove habitat for other uses are the major threats.

Conservation. The Wildlife Act of 1972 protects a number of marine species including turtles, dugong and coconut crabs, and provides the legislation under which protected areas may be established. The National Committee on Oceanography is responsible for coral reef management. In 1980, a Coral Reef Committee was set up under the Department of Science and Technology to pursue reef conservation. A field station for coral reef research was recently established in the Laccadive Islands. The following protected areas include or are adjacent to reefs (Cheung, 1995):

a. Gulf of Kutch Marine Sanctuary and Marine National Park
b. Wandur Marine National Park, Andaman Islands
c. South Butten Island National Park, Andaman Islands
d. Pitti Island Bird Sanctuary, Laccadive Islands
e. Gulf of Mannar Marine National Park

Conservation areas proposed for coral reefs are:

a. An area on the Malvan coast from Vengurla Rocks in the south to Sindurburg Fort in the north (Silas et al 1985)
b. Areas in the Andaman, Nicobar and Laccadive Islands

India has 21 protected sites for mangroves. Small forestation schemes have been conducted in many areas, notably in the Gulf of Kutch. Protected areas in the Gulf of Kutch, the Great Andaman Biosphere Reserve and three sites in the Sunderbans. In 1979 a National Mangrove Committee was established within the Department of Environment for the coordination of mangrove research and development programs (Spalding et al 1995).

The creation of protected areas in the Andamans, Nicobars, Laccadives and the Gulf of Mannar is considered a high priority in the Corbett Action Plan (Thorsell, 1985).

Table 2. Summary of important features of coral reef areas, India

Name/Location	Reef Size/Type	Visibility	Diversity	Use	Disturbances	Protection	Management	Recommendations
Gulf of Kutch (Marine Sanctuary and Marine National Park)	45.592 ha of which 16289 ha within Marine National Park Sandstone and coral reefs; patchy coral growth; reef fringe 30-40 islands in the Jamnagar coast within National Park; main islands Pirotan and Karumbhar	Poor due to sediment ~ 1 meter	32 hermatypic; 3 ahermatypic coral species in 24 genera; 12 species of soft corals in 11 genera; mangrove forests; large breeding colonies of avifauna; Turtles (Green, Olive Ridley and Leatherback); rare dugongs	Pearl oyster fishery is traditional; one of the 3 best pearl fisheries in the world; currently declining; chank fishery exists; Oyster shells are used to produce lime; traditional fishing is generally not near coral reefs	Cyclone damage; excessive collection of marine organisms; coral mining; dredging sand for cement; oil pollution severe threat to marine life as well as the proposed dam to harness tidal energy; Mangroves are damaged by the salt industry	Marine National Park (110 sq km) -1982 Marine Sanctuary (270 sq km) - 1980 Wildlife Protection Act of 1972	Yes; Administered by the conservator of forests	Improved zoning of park and sanctuary; Establishment of education centre with museum, laboratory; improve tourism and facilities; increase monitoring of extractive uses; manage pearl oyster fishery
Gulf of Mannar (from Tuticorin to Rameswaran near Adams Bridge on the southeast Indian mainland coast) Gulf of Mannar Marine National Park	Area of the islands about 600 ha; Marine National Park over 200 sq km. Coral reefs fringing the islands and possibly sandstone reefs; a discontinuous barrier reef	Affected by monsoons; coral mining and high sedimentation; however conditions and the clarity is better than in the Palk Bay	117 coral species; over 15 Acropora species and a large number of Montipora species; the reefs are better and more luxuriant than in the reefs of the Palk Bay due to better environmental conditions; sea grass beds are present; Green Turtles, Olive Ridley Turtles and Dugongs are dependent on the seagrass	Reef fishery; chanks and pearl fishery; ornamental shell trade; illegal mining of coral	Large scale coral mining; large domes of Porites and Favia collected for building materials; Dugongs and Turtles are heavily hunted; 3000 to 4000 turtles are killed in the Gulf of Mannar region (75% are Green turtles); the development of the Tuticorin Harbour; oil and indsutrial activities contribute to reef degradation	Marine National Park; the government of Tamil Nadu has banned the quarrying of massive corals; dead corals on landward sides of islands can be extracted under a lease; collection of marine organisms are allowed only for scientific purposes around the island of Krusadai	Coral mining legislation has not been implemented properly; Dugong hunting has been banned and awareness has been created among fishermen	Zoning for tourism development; education and scientific purposes have been recommended; certain areas have been recommended for total protection of marine life including dolphins and turtles as well as collection of seaweeds
Palk Bay Southeast India north of the Gulf of Mannar	Reef area is 25 to 30 km long and less than 200 m wide Fringing coral reef	Low due to heavy sediment loads; affected by northeast monsoon ~ 1 meter	65 species of corals have been recorded with a large number in the family Acroporidae; Turtles and Dugong are both found in the area; squid breeding grounds near Rameswaram; common seagrasses	Harvesting Holothurians; Chanks and Milk fish fry are important activities; Turtles are being harvested upto about a 1000 individuals annually; Dugongs are also taken	Sedimentation has caused large scale coral degradation especially with the monsoons; in at Mandapam 50 boats are engaged in quarrying the reef up to 250 cu m. per day	None	None	Milk fish catches need regulations; squid breeding grounds needs protection; a breeding reserve for Chanks has been recommended
Andaman Islands Wandur (Wandoor) Marine National Park; Bay of Bengal	There are about 500 islands, islets and rocks Fringing type; several hundred metres wide; reef lagoons present; much of the coastline contains fringing reefs; a barrier type reef is reported to the west	Heavy rainfall and some sedimentation; salinities are lowered during the rainy seasons and conditions for coral growth may become sub-optimal at times	Poritids and Favids are the chief reef builders; Coral growth profuse in outer edges of reef flats but patchy shorewards; 135 species of stony corals recorded for the Andamans; important nesting sites for the Leatherback; Hawksbill and Olive Ridley turtles; Dugongs recorded; Crocodiles; Coconut crabs are present; large mangrove stands; Tridacna contribute to reef structures	Fisheries and tourism; Trochus shells are exploited in large quantities as well as other ornamental shells; commercially valuable Holothurian species are harvested	Sedimentation has increased due to deforestation; Turtles, crocodiles and dugongs are exploited and are coming under increasing pressure; blast fishing occurs as well as coral mining; oil pollution has also been reported; Crown of Thorns starfish has been reported but the amount of damage has not been assessed	Wandur National Park has been declared; covers an area of 234 sq km of islands and reefs	The Wildlife wing of the Andamans and Nicobar Forest Department is responsible for National Parks; management is lacking at the Wandur National Marine Park	A Marine Biosphere Reserve has been suggested for Ritchie's Archipelago and a crocodile sanctuary on the southwest coast; the bombay Natural History Society has recommended the formation of an Oceanic Island National Park; a high priority should be the implementation of the Wandur National Marine Park

Name/Location	Reef Size/Type	Visibility	Diversity	Economic Use	Disturbances	Legal Protection	Management	Recommendations
Nicobar Islands about 300 km south of the Andaman Islands	Extent not known Fringing coral reefs are present with reef lagoons; there are patch reefs, knoll reefs, bay reefs mainly associated with the reef lagoons	Better than other reef areas in India and in Andamans	103 species of hermatypic corals from 39 genera recorded; Green, Hawksbill, Leatherback and Olive Ridley turtles nest on the islands; Best nesting site for the Leatherback turtle in the northern Indian Ocean; molluscs of economic value (Trochus) are common; mangroves are common with avifauna	Trochus shells are collected intensively and the islands are an important location for shell craft	Trochus shells overexploited; oil pollution poses a threat; Crown of Thorns starfish may have caused damage to the reefs	None	None	Nicobars together with the Andamans have been recommended as priority areas for conservation of coral reefs, turtles, and other marine life; licensing for extractive uses have been recommended
Laccadive Island including Minicoy	There are 11 major islands and atolls; 4 Major submerged reefs; 5 major submerged banks; the southern most island Minicoy is seperated from the others by the Nine Degree Channel Atoll islands with Fringing reefs; some islands with steep drop offs; lagoons are present on leeward side of the fringing reefs; all the atolls are fringed by good coral reefs	20-30 m	Most luxuriant coral growth in India; 69 species of hermatypic coral divided among 26 genera recorded from Minicoy; All common Indo-Pacific coral species with common genera belonging to Acroporidae, Faviidae and Pocilloporidae; Leatherback, Olive Ridley and Green turtles nest; Giant Clams are present; seagrass beds are common; diverse Avifauna recorded	Fishing and coconut cultivation; shells are collected for shell craft; Holothurians are common but may not be exploited at present	Crown of Thorns; coral mining and sedimentation due to dredging and the construction of harbours; over-exploitation of baitfish for Tuna fishery; Turtles are hunted; Oil pollution has been reported	Coral collection is banned except for scientific study; and turtles are also protected; legislation is not enforced	Sea erosion is checked by building barriers; dredging has been stopped; a marine research station established.	Recommendation for Minicoy include stopping de-forestation;, grazing of grasslands to reduce the sediment input into the coastal waters; immediate assessment of island biota; protected areas to allow the reef fish to recuperate; important nesting beaches for turtles to be protected; excavation, coral mining and blasting to be controlled immediately; establish guidelines for the extraction of sand

Sources : Pillai 1971; 1972; UNEP/IUCN 1988; Wafar and Whitaker 1992; Dorairaj 1994

Maldives

The Maldives form the central and largest part of the Laccadive--Chagos ridge and consist entirely of a chain of 22 low atolls and associated coralline reefs (Figure 4). The chain extends 764 km in a north-south direction. The Maldives has over 800 small vegetated coral sand islands, as well as many unvegetated sand cays which comprise only 300 sq km of land area with a maximum elevation of about 5 m above sea-level (Shepherd 1995).

The island biota have been well studied and marine fish are extremely abundant with about 1000 species recorded from the reefs and surrounding ocean (Munch-Petersen, 1982; 1985; Randall and Anderson, 1993). Live coral cover is generally excellent throughout the islands although several natural events over the past 30 years have affected coral growth. Crown-of-thorns starfish have been implicated in some coral predation and two periods of elevated sea surface temperatures in 1983 and 1987 may have caused some coral mortality (Allison 1995). The Green, Hawksbill, Leatherback and Loggerhead turtles all nest in the islands with the Hawksbill most abundant. Seabird nesting is very common in the less developed islands.

Historically and upto the present, the main export of Maldives has been fish caught mostly in deepwater. More recently, other resources such as souvenir shells, reef fish for aquariums, sharks, lobsters, turtle eggs and rays are utilized for local consumption or export (UNEP/IUCN 1988).

Coral rock has traditionally been used for housing and is still the main building material. It was estimated that about 94,000 cu meters of coral rock was mined during the period 1975-1985 (Brown and Dune 1986). More recent estimates, reflecting resort construction, suggest that between 200,000 and one million cubic meters of coral rock are mined annually (MFA 1994). Several uninhabitated reef areas within the atoll have been designated for extraction of coral rock but the activity is prohibited in most islands of the archipelago. Coral mining at this level has been shown to be non-sustainable especially when considered in the light of sea level rise (MFA 1994).

Tourism has expanded rapidly from 1972 when two resorts opened. Now there are 74 resorts in operation in the central atolls and annual arrivals exceed the permanent population of just over 200,000. The tourist industry provides 23.8 percent of government revenue and probably much more if sector related revenues such as airport taxes are included (Domroes 1985; Shepherd 1995).

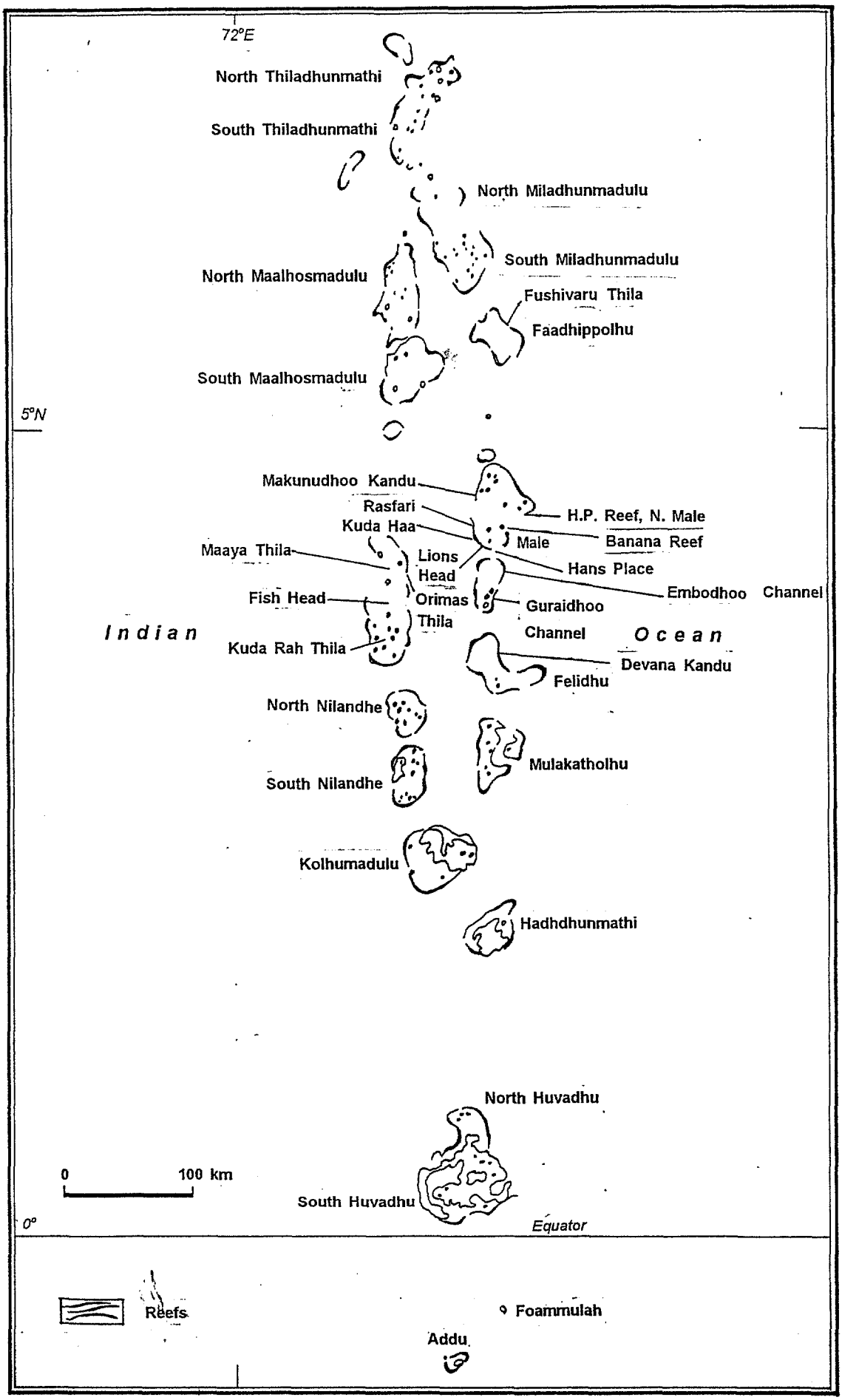

Figure 4. Maldive Islands and atolls (UNEP/IUCN 1988)

Environmental issues in the Maldives are of recent origin (except for coral mining) and directly attributed either to the modernization of fishing methods, the development of tourism or sea level rise. Tourism has increased the demand for coral rock for construction of resorts on small islands and requires the construction of groins to stabilize beaches and jetties to land boats. This changes the reef water flow and sediment movement and deposition patterns. Modification of beaches, dredging for sand, lack of building setbacks and poor solid waste disposal methods are all prevalent (Shepherd 1995). Increased demand for tourist products is causing greater exploitation of lobsters, sea turtle products and shells although these activities are generally regulated. Potential sea level rise is a concern given the very limited island elevation above mean sea level. As for all coralline islands, healthy reef growth is the best protection.

The Ministry of Planning and Environment has jurisdiction over most environmental concerns related to island development. The Ministry of Tourism regulates tourism development and provides guidelines for the use of islands. The Ministry of Fisheries and Agriculture (MFA) has banned the capture of sea turtles and regulates lobster fishing through size limits. It prohibits collection of black coral, giant clams, whale sharks and sea cucumbers using scuba. Aquarium fish cannot be collected on resort-island reefs (Edwards and Shepherd 1992). It is illegal to import or use spearguns (MFA 1995). The Environmental Protection and Preservation Act of Maldives approved in 1993 provides a good legal basis for protecting the atoll environment. Nevertheless, enforcement is poor and many illegal practices continue (Shepherd 1995).

Management efforts in recent years have included a voluntary monitoring program among resorts to watch for Crown-of-thorns starfish infestations. This program which was coordinated by the Ministry of Fisheries and Agriculture along with a periodic newsletter on the program and coastal topics helped raise awareness about coral reef conservation. Many studies have been conducted and reports submitted with recommendations for government action. Although the government has usually agreed with the suggestions, action has been slow because of institutional weakness and the difficulty of managing development in a large archipelago.

The Marine Research Section of the Ministry of Fisheries and Agriculture designated 15 reef sites as protected areas in 1995 (Table 8) (pers. com. Hassan, MFA). Other priorities as indicated in recent reports include: managing coral rock mining; implementing regulations on setbacks, jetty and resort construction and sewage outfalls; implementing regulations on waste disposal and exploitation of threatened species.

Pakistan

Coral reefs in Pakistan are not well developed and generally occur as corals or small colonies growing on hard substrate where conditions are favorable (UNEP/IUCN 1988). Lack of documentation of reefs in Pakistan precludes further discussion.

Mangroves are primarily found in the Indus River Delta where about 1,600 sq km occur. This arid area supports a monospecific growth of Avicennia which is resistant to extreme changes in temperature and salinity. Smaller patches are restricted to bays and river outlets along the coast.

Mangroves in Pakistan are used mainly for fuelwood, fodder and grazing by camels. Fishermen depend on the mangroves for capture of shrimp and crabs and for fuelwood and poles. An increase in salinity due to increasing use of Indus River water for agriculture is affecting the growth of mangroves. Pollution occurs mainly from Karachi.

Two large mangrove areas within the Indus River Delta, declared as protected forest reserves in 1957, are managed by the Forest Department. Efforts to establish mangrove plantations have resulted in some 50 sq km being planted in the Indus River Delta (Spalding et al 1995).

Sri Lanka

Coral reefs. Sri Lanka, with 17 million people and a coastline of about 1,585 km, has nearshore coral reefs of varying quality along about 2 percent (up to 32 km) of the linear coast (Swan 1983; Samarakoon and Pinto 1986; Baldwin 1991). Reefs are mostly of a fringing type in nearshore waters or patch reefs on rocky substratum at varying distances from the shore on the continental shelf. True coralline reefs are few and most with their general locations known in the west and northern areas, have been surveyed (De Silva and Rajasuriya 1989). Coral reefs occur around the Jaffna Peninsula in the north, from Trincomalee to Kalmunai along the east coast, and from Tangalle in the south to Akurala in the southwest. Coral reefs in the northwest are found from Mannar Island southward to the Kalpitiya Peninsula. At three locations along the western coast (at Vankalai, Silavathurai and Bar Reef), barrier type reefs are present. Corals have also colonized two underwater ridges called the Great and Little Basses off the southeastern coast of the island. Elsewhere, corals provide a superficial cover on reefs of beach rock and rocky sandstone substrates (Figure 5) (Rajasuriya 1991a; 1991b; Rajasuriya and White 1995).

A total of 183 species of stony corals divided among 68 genera have been recorded (Rajasuriya and De Silva 1988; Rajasuriya 1994). Over 300 species of reef and reef associated fish have been identified belonging to 62 families (Rajasuriya 1993). In addition, offshore patch reefs are frequented by Whale sharks and five species of sea turtles.

Ecological surveys of the most important reefs of the country have shown that the reefs of best condition are associated with the barrier type reefs off the northwest coast at Kalpitiya (Bar Reef) and on the Little and Great Basses ridges off the southeast coast. Live hermatypic coral cover on some reefs exceeds 50 percent in the northwest. Many other nearshore reefs have a low cover of living coral and high percent of sand or rocky substrate in relation to living substrates (De Silva and Rajasuriya 1989).

Many coral reefs in Sri Lanka have been severely degraded by human induced damage as indicated in Tables 3 and 4. In addition, coral reefs on the northwest and the east coasts are under threat from periodic infestations of the Crown-of-thorns starfish (De Bruin 1972; Rajasuriya and Rathnapriya 1994). The most significant human impact on the reefs is by the increasing amount of sediments pouring into the ocean from erosion due to deforestation, poor agricultural practices and construction. A second and equally important impact stems from the historical and continuing coral mining along parts of the south and eastern coastlines (Ekaratne 1989; CCD 1990; Herath 1990; Hale and Kumin 1992; Simmons 1993; Rajasuriya and White 1995). This removal of reef rock from dead and living reefs has removed large areas of reef habitat and caused increasing coastal erosion along those stretches of coast where mining is most prevalent. This problem has not been easy to address because of the economic benefits accruing to the more than 5,000 people employed in coral mining and processing (Premaratne 1984; Hale and Kumin 1992).

Because most reefs are easily accessible, they are also used for fishing, collection of live marine organisms for the aquarium industry and for tourism. In 1985, about 25,000 to 30,000 boxes of ornamental marine fish and invertebrates were exported valued at about $US2 million (Wood 1986). Fishing with explosives, use of fine mesh nets and hand collection while diving are increasingly common in areas where law enforcement is not perceived to be a threat. Corals within reef lagoons are often damaged by boat anchoring and the discharge of waste oil into the sea from fishing or tourist boats (De Silva and Rajasuriya 1985; Nakatani et al 1994).

Coastal waters in Sri Lanka are the main dumping ground for solid wastes and sewage from cities, towns, hotels and factories located in the coastal areas. A cottage industry that produces coconut fiber products requires calm back waters of fringing reefs

to season the fiber which reduces the oxygen in the water causing pollution and promoting algal growth.

Sea level rise is a concern in Sri Lanka because much of the coast is naturally eroding from the wave energy of the Indian Ocean, particularly during the southwest monsoon. Protective structures have been built to protect beaches, vegetation and human development. Because sea level rise will exacerbate erosion, coral reefs are seen as important natural erosion barriers.

Hoffman (1976), De Silva (1981, 1983 and 1985a and b), De Silva and Rajasuriya (1985), Salm (1981), Ohman et al (1993) and Rajasuriya and White (1995) discuss the status of reefs in Sri Lanka and their need for management. An overview of the exploitation of coral reef fishes for the aquarium trade was completed by Wood (1986).

Seagrass beds occur in most coastal estuaries and lagoons but are primarily associated with the Puttalam, Negombo, Kokilai, Jaffna and Batticoloa Lagoons. Extensive meadows are found from the Puttalam Lagoon in the northwest coast to the west of Jaffna Peninsula along the western part of the Gulf of Mannar. They also extend north to Rameshwaram on the southeast coast of India. This area along with the south Indian coast forms a system of coral reefs, mangroves and seagrass beds and is responsible for the high fisheries production. Twelve species of seagrasses have been recorded in Sri Lanka (Baldwin 1991). Trawling is the main threat to seagrass beds.

Mangrove forest cover in Sri Lanka is limited to about 84 sq km (Spalding et al 1995). The Jaffna Peninsula in the north supports much growth while the largest single area is around the Puttalam Lagoon. Low tidal ranges along the entire coast and high wave energy exposure on the south coast preclude the development of wide areas of mangrove. Major uses include firewood, tannins and poles for construction. More recently aquaculture development has destroyed much of the mangrove forest in the Chilaw and Puttalam areas on the west coast.

Conservation. Legislation which directly controls the management of coral reefs is the Coast Conservation Act No. 57 of 1981, its amendment of 1988 and the national Coastal Zone Management Plan it mandates. Other laws include the National Environmental Act No. 47 of 1980 and its amendment of 1988; the Fauna and Flora Protection Ordinance No. 2 of 1937 and its amendments of 1937, 1938, 1970 and 1972; the Fisheries Ordinance No. 24 of 1940 as amended in 1973; and the National Aquatic Resources Research and Development Agency Act No. 54 of 1981. All mangroves are legally protected with the Forest Department responsible for implementation.

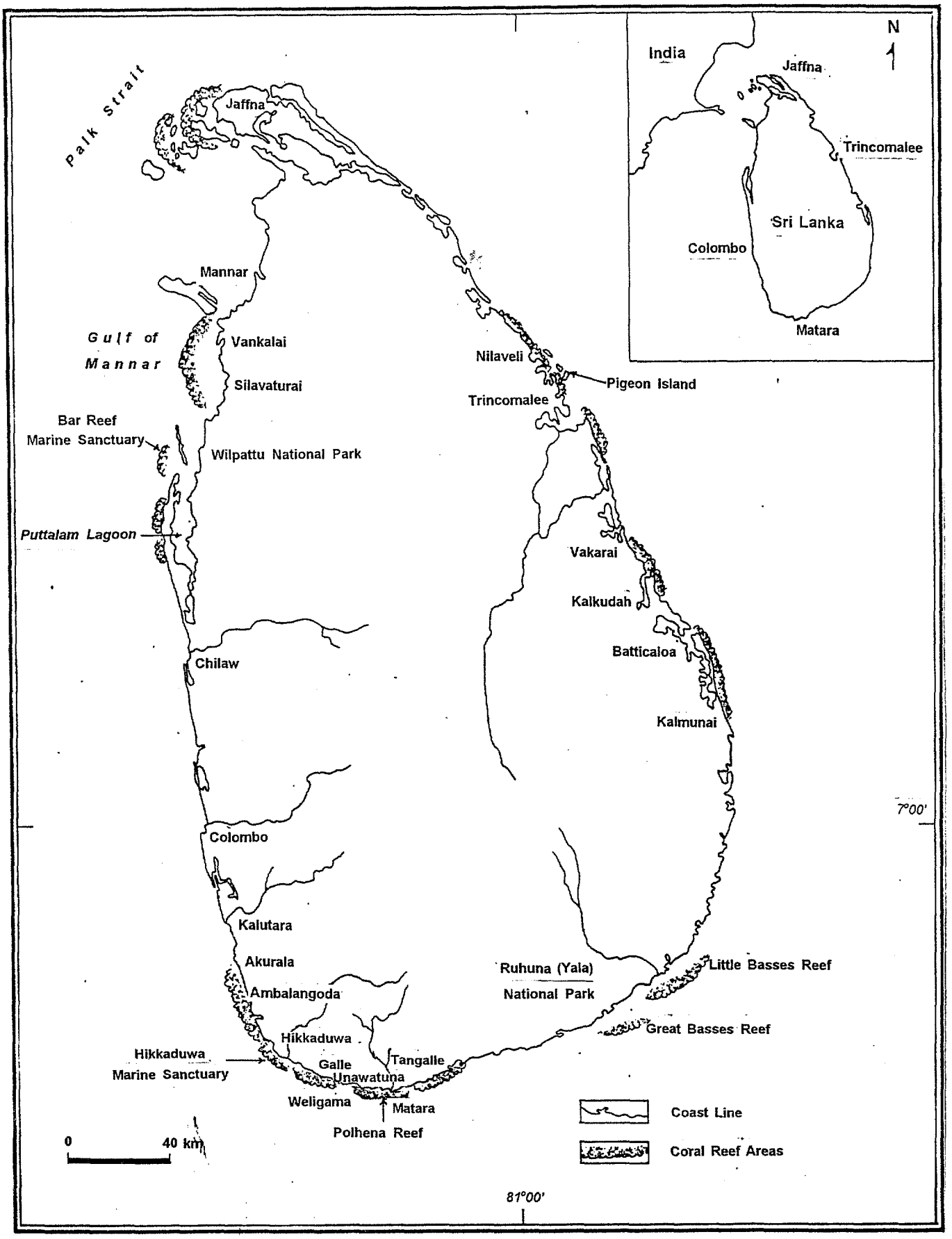

Figure 5. Recorded coral reef locations in Sri Lanka
(Rajasuriya and White, 1995)

Table 3. Reef location, status and cause of damage or threat, Sri Lanka

Location*	Status	Causes of Damage or Threats
Bar Reef	Undegraded	Destructive fishing, Crown of Thorns, ornamental fish collection, boat anchors
Kandakuliya	Heavily degraded	Destructive fishing, boat anchors, ornamental fish collection
Talawila	Degraded	Destructive fishing, boat anchors, ornamental fish collection
Chilaw	Partially degraded	Destructive fishing
Negombo	Degraded	Destructive fishing, sedimentation
Colombo	Degraded	Destructive fishing, pollution, silt, ornamental fish collection
Ambalangoda	Degraded	Destructive fishing, sedimentation
Akurala	Degraded	Coral mining, destructive fishing
Hikkaduwa	Degraded	Boat anchors, glass bottom boats, pollution, siltation, ornamental fish collection, reef walking, oil
Galle	Degraded	Destructive fishing, ornamental fish collection, blast fishing pollution, oil, sedimentation
Unawatuna	Partially degraded	Ornamental fish collection, boat anchors, pollution, reef walking
Weligama	Degraded	Ornamental fish collection, boat anchors, oil from boats, silt
Polhena	Degraded	Pollution due to coconut fibre seasoning, ornamental fish collection, sedimentation
Tangalle	Partially degraded	Ornamental fish collection, reef walking, destructive fishing
Great & Little Basses	Undegraded	Unregulated fishing and diving for spiny lobsters, destructive fishing
Batticoloa & Trincomalee	Partially degraded	Destructive fishing, ornamental fish collection, coral mining, Crown of Thorns, boat anchors

* Locations shown on Figure 5.

Sources: De Silva 1985a; Rajasuriya and De Silva 1988; Rajasuriya 1991 a and b; Ohman et al 1993; Rajasuriya and White 1995

Table 4. Human and natural factors impacting reefs in Sri Lanka and their relative importance and extent

Factors	Relative Importance (5 high to 1 low)	Extent
HUMAN CAUSED		
Sedimentation from poor landuse practices and construction	5	Pervasive in nearshore areas
Coral mining in beach and marine waters	5	Many sites on southwest coast
Destructive fishing methods		
Blast fishing	4	Site specific in many areas
Bottom set nets	4	
Tourism related activities		
Boat anchors	2	Few sites
Collection by tourists	1	Few sites
Pollution		
Oil from boats	3	Pervasive near harbors
Seasoning of coconut fiber	1	Few areas
Collection of ornamental fish and reef organisms	4	Many reefs
Overfishing	4	Nearshore reefs
NATURAL CAUSED		
Crown of Thorns starfish	3	Localized in a few reef areas
Wave action from storms	2	Southeast, south and southwest

Sources: ICRMP, 1986; De Silva, 1985a; Nakatani et al 1994; Ohman et al 1993; Rajasuriya and White 1995.

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Environmental problems were first addressed in specific terms in the Coastal Zone Management Plan approved in 1990 by the Cabinet of Ministers (CCD 1990). The National Environmental Action Plan of 1991 coordinated by the Central Environmental Authority also addresses many issues. A more recent policy document, Coastal 2000: A Resource Management Strategy for Sri Lanka's Coastal Region (Olsen et al, 1992), has been accepted by the government as a guide for management of coastal resources in the country. This document calls for a decentralized and participatory approach to management of resources including coral reefs, seagrasses and mangroves.

Although an Inter-Ministerial Committee formed by the National Aquatic Resources Agency (NARA) in the early 1980's identified more than 20 marine and coastal sites around the island to be declared as reserves or sanctuaries, only two that contain coral reefs are legally protected. These sites are the Hikkaduwa Marine Sanctuary (declared in 1979) on the southwest coast and the Bar Reef Marine Sanctuary (1992), off the northwest coast. They are marine sanctuaries under the Fauna and Flora Protection Ordinance of the Department of Wild Life Conservation. Lack of proper enforcement strategies, staff, adequate funds, and of concerted awareness programs are some of the major constraints in the implementation of the marine sanctuaries.

In 1992, the Hikkaduwa Sanctuary became the focus of an intensive Special Area Management (SAM) project which is addressing, through participatory planning and implementation, the contributing causes of deterioration of the sanctuary coral reef (White and Samarakoon 1994).

Management recommendations by Rajasuriya and White (1995) for Sri Lanka with some relevance for other countries include:

1. The legally declared marine sanctuaries of Hikkaduwa and Bar Reef, and several proposed sanctuaries should be given prime consideration for active management through the collaboration of national and local government with active participation of the community user groups of the area (Pernetta 1993; White and Samarakoon 1994).
2. Coral mining needs to be addressed through a comprehensive economic program which removes the market for limestone. This can be accomplished by making inland limestone more accessible to the present coral miners and by allowing some imports of cement to supplement the market (Herath 1990; Hale and Kumin 1992). In addition, viable economic alternatives in the immediate coastal zone need to be developed along with the disincentive of improved law enforcement.
3. The increasing incidence of physically destructive fishing methods such as use of explosives can be dealt with through education campaigns against such practices and improved law enforcement as a deterrent.

4. A standardized and expanded coral reef monitoring and documentation program to be implemented under the guidance of NARA with collaboration of Universities and NGOs interested in coastal conservation is needed to provide current information on the status of the resource and its management.

REGIONAL ANALYSIS AND SUMMARY

Reef Extent and Priority Areas for Management

The largest and richest reef areas in the Region occur in the Chagos, Maldives and the Laccadive Islands (Table 5). Chagos has 21,000 sq km of shallow water which is a very large area for potential reef development. Chagos is reported to have the most pristine coral reefs remaining in the Indian Ocean while the Maldives and Laccadives are a close second. The Nicobar and Andaman Islands have much fringing reef in good condition. Many valuable but vulnerable species and resources occur in all these island areas and are reflected in the ratings of Table 5.

Essentially all the reefs associated with mainland coasts are degraded or in varying states of disturbance. Nevertheless, isolated areas of reef which occur offshore in Sri Lanka and in the Gulf of Mannar, India are in good condition and warrant management attention. Priorities for management based on area and condition of reefs, and the practicality for management, are shown in Table 5.

Human and Natural Impacts on South Asian Reefs and Mangroves

Table 6 summarizes the main threats to reefs in the region. Many of these threats are common to all reef areas but occur at different levels of intensity. Sea level rise is a particular concern in the low-lying islands and where natural erosion or wave energy is high, especially if coral and sand mining continues unabated in these areas. The question is whether rates of vertical accretion of coral reefs can keep up with the predicted rate of sea level rise, the best guess for which is 4 mm/year (Edwards 1995). The overall estimate of the sustained rate of vertical accretion of 10 mm/year indicates that healthy reef ecosystems can survive. However, human and other natural disturbance can profoundly influence their ability to respond to sea level rise and are the variables of most concern for the survival of South Asian reefs.

Coral mining is a regional problem that occurs in India, Sri Lanka and Maldives. Sedimentation is a common problem on all mainland reefs of India and Sri Lanka. Pollution of various kinds is common along the mainland coast of India and parts of Sri

Table 5. Status and priority of areas for management

Country/Site	Resource Status	Regional Value & Priority Rating*
Bangladesh		
St. Martin Is.	Degraded	1
Chagos Archipelago		
Great Chagos Bank	Excellent	10
Nelson Island	Excellent	10
India		
Gulf of Kutch	Marginal	3
Gulf of Mannar	Variable	5
Palk Bay Islands	Poor	2
Andaman Islands	Generally good	8
Wandur National Park	Good/excellent	9
Ritchie's Archipelago	Good/excellent	8
Nicobar Islands	Good/excellent	8
Laccadive Islands	Good/excellent	9
Maldives		
15 Marine Reserves	Excellent	10
Reefs near Male	Good/poor	5
Reefs near resorts	Good/excellent	9
Reefs near villages	Generally good	7
Sri Lanka		
Bar Reef Sanctuary	Good/excellent	9
Hikkaduwa Sanctuary	Moderate	7
Unawatuna Bay	Good	7
Basses reefs (Yala)	Excellent	8
Other nearshore reefs	Moderate to poor	3
Other offshore reefs	Generally good	5

Regional Value and Priority Rating based on a synthesis of overall information available for this report relating to size, condition, diversity, ecological value and threatened species presence.

* Rating of 1 (low) to 10 (high).

Table 6. Known threats to reefs

	Erosion/ Land Clearance/ Sedimentation	Construction/ Dredging/Mining	Pollution-- Industrial, Domestic etc.	Over-collection	Destructive Fishing	Tourism Impacts	Natural	
							Acanthaster	Storms/ Surge
Bangladesh	5	2	1	5	5	3	1	5
Chagos	0	1	0	0	0	0	?	1
India								
Gulf of Kutch	5	5	4	5	5	?	?	3
Palk Bay	5	5	3	5	5	?	?	1
Gulf of Mannar	4	5	3	5	5	?	?	1
Andaman	4	3	2	3	2	1	2	2
Nicobar	1	2	1	3	2	1	2	2
Laccadive	1	3	2	2	1	1	1	2
Maldives								
Male	4	4	4	4	3	2	2	1
Resort Islands	2	2	1	1	1	1	2	1
Village Islands	1	1	0	3	2	0	1	1
Sri Lanka*								
Nearshore	5	5	3	5	4	2	2	1
Offshore Reefs	1	0	0	4	4	0	2	1

* See Table 4 for Sri Lanka

Relative Importance (5 High to 1 Low)
0 - No problem
? - No information

Sources: UNEP/IUCN 1988; Rajasuriya and White, 1995; MFA 1994; Ramanujan, 1994.

Lanka. Overfishing is more common in heavily populated coasts of India and Sri Lanka and is less a problem in Maldives or other island areas. Tourism is creating a demand for some reef products such as souvenir shells, turtle products, food fish, primarily in Sri Lanka and Maldives. There is still relatively little tourism in the Laccadive, Nicobar and Andaman Islands and virtually none in Chagos.

The main threats to mangroves, which occur with most abundance in India, Bangladesh, Pakistan and Sri Lanka, are from conversion of mangrove habitat to other uses such as aquaculture and urban development. Unsustainable uses of products include cutting for fuelwood and timber. Natural causes of destruction are from cyclone winds and storm surges which affect the Bay of Bengal along the Indian and Bangladesh coasts.

Laws and Institutions Governing Coral Reef Management

Current laws affecting the protection of coral reefs have been discussed earlier along with primary implementing institutions. Table 7 lists the important government institutions in each country with jurisdiction over coral reefs and coastal management and non-government organizations with interests in reef conservation. In most countries, there is overlap among institutions responsible for coastal resources management and some ambiguous laws or regulations which are difficult to implement.

Protected Areas--Established and Proposed

Table 8 lists the existing and proposed or recommended protected areas adjacent to or including reefs. Although the list is quite long, many are very small areas and most have little or no active management. Those benefiting from the best protection by default are those furthest removed from human disturbance in the Chagos Archipelago or in parts of the other island groups. Sri Lanka has one small protected reserve, Hikkaduwa which covers 100 hectares, where management is beginning. The Maldives recently established 15 sites for protection. India has several national parks but with minimal field implementation.

Current Research and Management Projects

Table 9 lists by country all the major research, monitoring and management projects which relate to coral reef ecosystems and their conservation. Although there are numerous projects, they tend to be small and create little overlap of effort. In both the Maldives and Sri Lanka, coral reef conservation is increasingly linked to integrated coastal management approaches with community and local government involvement.

Table 7. Agencies and organizations with jurisdiction over or concern with reef conservation

INDIA (Tamil Nadu State)

Government Organizations

Tamil Nadu State Pollution Control Board (TNPCB). Responsible for environmental planning, management and monitoring of the water, soil and air media; all industries in the state function with permission from the Board and effluents are periodically monitored; establishment of new industries depends on installation of treatment plants; main objective of the TNPCB is pollution control.

***Department of Environment, Forests and Wildlife, New Delhi.** Implements most environmental legislation and supports environmental research and scientific projects in Tamil Nadu.

Council of Scientific and Industrial Research (CSIR). This quasi-governmental organization supports environmental research, conducts competitive exams nationwide for postgraduate students and funds scientific projects.

Other Research and Management Organizations

Departments attached to Central Government Ministries which sponsor and coordinate environmental work in Tamil Nadu--Department of Science and Technology, Department of Ocean development.

Environmental Research Organizations--Forest Research Institute, Wildlife Institute of India, Indian Institute of Technology, the Fisheries Research Institute, the Central Marine Fisheries Research Institute, Central Institute of Brackishwater Aquaculture, Central Inland Capture Fisheries Research Institute

National Committee on Oceanography--concerned with all coral reef matters.

Universities

V.O. Chidambaram College, Tuticorin, Tamil Nadu--research in Gulf of Mannar

The Anna University, Madras. Center for Environment Studies (focus on pollution); the Water Resources Department (Ocean Data Center); Remote Sensing Center (coastal mapping in Tamil Nadu).

Annamalai University, Parangipettai. Center for Advanced Study in Marine Biology.

Pondicherry University, Pondicherry. School of Ecology and Environmental and Sciences.

Jawaharlal Nehru University, New Delhi. School of Environmental Sciences.

Berhampur University, Berhampur. Postgraduate Department of Marine Sciences.

Cochin University of Science and Technology. School of Marine Sciences.

Manomaniam Sundaranar University. Rajakkamangalam. Institute for Artemia Research and Training.

Tamil Nadu Veterinary and Animal Sciences University. Fisheries College and Research Institute.

Non-Governmental Organizations

The Madras Science Foundation
Indian Environmental Society
Society for Andaman and Nicobar Ecology

MALDIVES

Government Organizations

***Marine Research Section (MRS), Ministry of Fisheries and Agriculture.** Established in 1984 as the research arm of the Ministry of Fisheries. Conducts research on all major fisheries in the country, assesses and monitors the status of marine ecosystems, develops and applies new fishing gear and techniques.

***Environment Section and Environment Research Unit, Ministry of Planning and Environment.** Coordination of the government's environment programs and environmental information in the Maldives; ensures that environmental considerations are part of the planning process of major economic activities; the Environmental Research Unit (ERU) carrys out research on environment and produces data for programming, planning, enforcing and regulating environmental matters.

Maldives Water and Sanitation Authority (MWSA), Ministry of Health and Wealth, Male. Ensures acceptable drinking water in the Maldives and for Male's sewage system; has a well-equipped laboratory to carry out physical, chemical and bacteriological water analysis.

Ministry of Public Works and Labour. Manages harbors, maintains jetties and seawalls in Male; carries out dredging and harbour construction in Male and other islands.

Ministry of Tourism. Sets guidelines for resort island development.

Non-Governmental Organizations
Blue Peace, Ma. Kelaavi, Male
Eco-care, Male
Forum of Writers on Environment, Ministry of Planning and Environment, Male
Maldives Association for Tourism Industries, Male
Veshi, Male

SRI LANKA**

* **Coast Conservation Department** (CCD): Planning, development and regulatory jurisdiction from 2 km seaward to 300 meters landward, with extended authority where inland waterbodies meet the sea. Responsible for building shoreline protection structures. Issues permits for coastal development activities on the basis of their location, impact on the coastal zone and applicable policies of the CZM Plan.
* **Central Environmental Authority** (CEA): Principal coordinating agency for environment-related activities. Establishes national environmental standards. Responsible for coordinating the National Environmental Action Plan, and overseeing Sri Lanka's environmental impact assessment process.
* **Ministry of Fisheries and Aquatic Resources**: Management authority over fishery resources and the development of the fishery industry.
* **Department of Wildlife Conservation** (DWLC): Manages national parks and protected areas, responsible for endangered species and trade in wildlife including marine areas and species.
* **National Aquatic Resources Agency** (NARA): National research agency for all aquatic resources and management thereof.

Urban Development Authority (UDA): Planning and regulatory authority over building specifications within one kilometer of the coastline.
Ceylon Tourist Board: Planning authority for tourist facilities and development.
Ceylon Fisheries Harbors Corporation: Responsible for fishery harbor development.
Institute of Fundamental Studies--Facilities for pesticide, heavy metal and soil/sediment analysies.

Universities
University of Colombo. Chemical analyses of water including heavy metals, biological and microbiological studies of water; coral reef research.
University of Kelaniya. Physico chemical tests of water, biological analysis of water and benthos.
University of Peradeniya, Department of Geography. Center for Environmental Studies conducts training for Environmental Impact Assessment and for Coastal Zone Management; research on coastal processes.

Non-government Organizations
Wildlife and Nature Protection Soceity--general conservation of wildlife and habitat, oldest environmental NGO in Sri Lanka.
Sri Lanka National Mangroves and Coastal Habitat Conservation Fund--Mangroves and coastal resources conservation and management.
Institute for Alternative Development and Regional Cooperation--Environmental research and community based environmental management.
Nature Foundation--Dissemination of environmental sciences information through video production and presentation.
Environmental Foundation Ltd.--Legal advocacy, environmental law, nature resource rights, education and research.
Sri Lanka Environmental Journalists Forum--Environmental awareness through the mass media.
Organization for Environmental Education--Environmental information dissemination through drama production and story books.
March for Conservation--Environmental education and teacher training.

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* Those agencies with direct authority over coral reef resources management or with research interest.
** There are thirty-two government agencies that have jurisdiction over coastal areas and resources in Sri Lanka.

Sources: Adapted from Hale and Kumin (1992); Rajasuriya and White 1995. Holmgren 1994.

Table 8. Existing and proposed or recommended protected areas adjacent to or including reefs

	Year Established	Management		Proposed/ Recommended
		Yes	No	
Bangladesh			+	+
St. Martin's Island				
Chagos				
*Great Chagos Bank			+	+
*Nelson Island			+	+
India				
Gulf of Kutch Marine Sanctuary	1980	+		
Marine National Park	1982			
Gulf of Mannar Marine National Park	?	?	+	
*Wandur Marine National Park, Andamans	1986	?	+	
Pitti Is. Birds Sanctuary, Laccadives	1979	?	+	
*Ritchies' Archipelago, Andamans			+	+
South Butten Island National Park, Andamans			+	
*Nicobar Is			+	+
Malvan coast				
(Venguru Rocks to Sindurburg Fort)			+	+
Anjadip Is. (East Coast)			+	+
Maldives (15 sites recommended in 1994)	1995			
*Fushivaru Thila, Lhaviyani		+		
*Makunudhoo Kandu, N. Male		+		
*Rasfari, N. Male		+		
*H.P. Reef, N. Male		+		
*Banana Reef, N. Male		+		
*Kuda Haa, N. Male		+		
*Lions Head, N. Male		+		
*Hans Place (Kikki Reef), N. Male		+		
*Embodhoo Channel, S. Male		+		
*Guraidhoo Channel, S. Male		+		
*Maaya Thila, Ari		+		
*Fish Head, Ari		+		
*Orimas Thila, Ari		+		
*Kuda Rah Thila, Ari		+		
*Devana Kandu, Vaavu		+		
Sri Lanka				
*Hikkaduwa Marine Sanctuary	1979	+		
*Bar Reef	1992		+	
*Great and Little Basses Reefs Marine Sanctuary adjacent to Yala National Park			+	+
*Unawatuna Bay			+	+
Pigeon Island Sanctuary	1974		+	
Pasekudah and Kalkudah Bay Marine Sanctuary			+	+
Thennadi Bay			+	+
Great and Little Sober Islands, Trincomalee	1963		+	
Paraitivu Island, Jaffna	1973		+	

* These sites known to have coral reefs in good to excellent condition.

Sources: UNEP/IUCN, 1988; MFA 1995; Rajasuriya and White, 1995; Cheung 1995.

Table 9. Research and management projects

INDIA

Field investigation to design a strategy to protect the coral islands and the reef system of Gulf of Mannar, India. Dr. N. Ramanujam of V.O. Chidambaram College, Tuticorin, Tamil Nadu, has sought assistance from Earthwatch, Inc., USA to begin a continuous monitoring scheme in 1996.

Monitoring of reefs in Laccadives. Dr. Wafar at National Institute of Oceanography, Goa

Surveillance of reefs, seagrasses and mangroves. The Zoological Survey and the Botanical Survey of India

MALDIVES

Coral reef monitoring. The Marine Research Section (MRS) in collaboration with McMaster University of Canada conducted a reef-monitoring project funded by the International Centre for Ocean Development (1990-92); ongoing.

Rehabilitation of degraded reefs using artificial reef blocks and monitoring for the potential impacts of climate change on coral reefs. Administered by the Centre for Tropical Management Studies, University of Newcastle-upon-Tyne, U.K. and the Marine Research Section; supported by Overseas Development Administration (ODA), U.K; ongoing.

Shark fishery survey. An assessment of the status of the shark fishery to plan rational exploitation of the resource; MRS with funding and expertise from FAO; completed in 1993.

Marine ecosystem and coral reef survey. Expands the on-going monitoring activities of the MRS to other islands and atolls; ongoing.

Solid waste management for rural islands, resorts and future urban centres in the Maldives. Reviews current solid waste management problems and is trying to improve the capabilities of the government departments to monitor and enforce appropriate waste disposal standards.

Reef fisheries and participatory monitoring for integrated reef resources management. Involvement of fishing communities in fisheries and reef condition monitoring. FAO and the Bay of Bengal Programme; ongoing through 1999.

Establishment of 15 protected areas. The MRS has completed the legal work for protected area status for 15 popular diving sites, 1995.

SRI LANKA

National Aquatic Resources Agency (NARA). Activities supported by Swedish Agency for Research Cooperation with Developing Countries (SAREC) include:

Coral reef research programme of NARA--development of a management plan for the Northwestern Province, in Kalpitiya Peninsula and for the marine sanctuary at Bar Reef, ongoing; development of a Coral Reference Collection for Sri Lanka. Future programme: (1996-97) Reef monitoring in the Southeast including Great and Little Basses.

Marine Biology Resources Division of NARA--development of a resource profile and management plan for Puttalam and Mundal estuarine system.

Artificial reef habitats for spiny lobsters are being introduced in the southern coatal waters under an Asian Development Bank funded Project.

Coast Conservation Department (CCD). Projects supported by DANIDA, German Technical Assistance (GTZ) and Canadian International development Agency (CIDA) include technical assistance in coastal engineering, educational activities in coastal erosion and coral mining.

Coastal Resources Management Project (CRMP) of the University of Rhode Island and USAID. This project assists the Coast Conservation Department (CCD) to implement the national CZM plan, to revise the plan and to implement two Special Area Management sites with coral reefs (see below); it also assists the National Aquatic Resources Agency (NARA) to do research for management planning at the sites and on reef conservation; ongoing through 1996, $US300,000/year.

Hikkaduwa Special Area Management Project. This project assists the CCD, the Department of Wildlife Conservation and NARA to improve the management of the Marine Sanctuary and coastal strip of the town; supported by the CRMP of URI and USAID; ongoing to 1996; $US60,000/year.

Rekawa Lagoon Special Area Management Project. This project assists the CCD and the Divisional Secretariat to improve the management of the lagoon resources and the surrounding ecosystems including coral reefs; supported by the CRMP of the URI and USAID; ongoing through 1996; $US60,000/year.

Special Area Management Plan Implementation. This is proposed under the National Environmental Action Plan for Sri Lanka; it will implement plans in 5 sites (Hikkaduwa, Rekawa Lagoon, Unawatuna, Bar Reef and Bundala Lagoon) four of which have coral reefs. (1996-2000).

Ornamental Fish Recruitment. At specific sites on the west coast, NARA and the Marine Conservation Society of England are researching levels of effort of aquarium fish collection and fish recruitment (1996-1999).

Sources: Holmgren 1994; Rajasuriya and White 1995; Ramanujam 1994.

Recommendations for Management

Research and monitoring activities need to be improved and expanded in the region. Standardization of monitoring methods and establishment of communication links among the research bodies in the region is essential. This will raise awareness about the plight of coral reefs and provide more practical feedback to managers, concerned agencies, non-government organizations and citizens. Improved regional linkages will have beneficial results. An example is monitoring for oil pollution and sharing technical skills in detection, clean-up and control. Another is sharing success and failures of local and national management approaches. Opportunities for research and monitoring both at the national and regional levels include:

a. Chagos could be used as a reference area for the Indian Ocean since the reef ecosystems are less disturbed than anywhere else;
b. Selected reef sites in each country could be selected and protected as reference areas for coral reefs of that country;
b. The various Indian institutions such as V.O. Chidambaram College in Tuticorin, Tamil Nadu and the National Institute of Oceanography in Goa, among others, could agree to designate certain institutions as responsible for monitoring limited areas, the results of which are standardized and shared nationally and regionally;
c. The Marine Research Section, Ministry of Fisheries and Agriculture which assesses and monitors the status of coral reefs in Maldives could expand its work to include a systematic monitoring program, the methods and results of which are shared regionally;
d. The National Aquatic Resources Agency (NARA) of Sri Lanka could link with several interested universities (e.g. Colombo University) to strengthen their research and monitoring program in reef areas which would also be shared regionally; and,
e. Regional monitoring of the effects of human and natural disturbances in relation to human management responses would contribute to the ability of each country to respond to the management needs created by the various threats.

Capacity building for management is essential in the region. This can be accomplished through the experience of field pilot projects which accomplish conservation of coral reef areas. Coastal zone management programs, such as that in Sri Lanka can include Special Area Management projects which address the needs of coral reef conservation within an integrated legal and institutional framework. Training personnel to manage integrated programs and to encourage community-level participation will be

essential (White et al 1994). Given the extent of coral reef resources in the region, there are very few trained personnel with a good background in resource management skills. There is a need for university level and special training in management oriented research and field implementation methods.

Funding for comprehensive and integrated approaches to coral reef management is needed. Solutions to coral reef conservation must be sought through integrated Coastal Zone Management (CZM) programs with a duration which allow long-term and balanced plans. This will require perspective, planning, funding, training and successful experiences (White et al 1994; Rajasuriya and White 1995).

Market and private interventions can be tested to improve involvement of citizens and resource users in conservation. Tourism developers could be encouraged to lease adjacent reef areas for tourist viewing purposes if they are willing to fully protect the area. Marine eco-tourism, underdeveloped in the region, can be pursued and monitored.

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